

Application No.: 10/571,507
Filing Date: March 10, 2006

REMARKS

In response to the Office Action, Applicant respectfully requests the Examiner to reconsider the above-captioned application in view of the foregoing amendments and the following comments.

Election/Restrictions

Applicant has retained Claims 6-8, 11, 12, and 22-26 as withdrawn claims, as these claims are believed to be eligible for rejoinder upon allowance of "elected claim."

The nonelected invention; i.e., "a process for forming, on a substrate, an electroconductive layer with good conductivity having a fine shape, which is consisting of a sintered product layer of metal nanoparticles using the metal nanoparticle dispersion as claimed in claim 1" is technically equivalent to such invention "a method of using the metal nanoparticle dispersion as claimed in claim 1 for forming, on a substrate, an electroconductive layer with good conductivity having a fine shape, which is consisting of a sintered product layer of metal nanoparticles". Thus, the nonelected invention may be rejoinable subject in the case when the metal nanoparticle dispersion as claimed in claim 1 is allowable.

Consequently, upon allowance of the elected claims, Applicant respectfully requests rejoinder of withdrawn Claims 6-8, 11-12, and newly added 22-26, which ultimately depend from the elected Claim 1

Discussion of the Claim Rejections Under 35 U.S.C. § 112

Claim 20 has been rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. The Examiner asserts that a multiple use of conjunctions and a lack of punctuation render the alternative grouping of Claim 20 indefinite. As shown above, Claim 20 has been amended for clarification. Applicant respectfully requests withdrawal of the rejection.

Discussion of the Claim Rejections Under 35 U.S.C. § 103

Claims 1-5, 9, 10, 19 and 21 have been rejected under 35 U.S.C. § 103 as being unpatentable over Hutchinson (U.S. Publication No. 2003/0077625). Applicant respectfully submits that Claim 4 is allowable over Gray and Reilly et al., as discussed below.

Discussion of Patentability of Independent Claims 1

As amended herein, Claim 1 recites, among other things," the coating of said one or more compounds having the group containing the nitrogen, oxygen or sulfur atom on the surface of the metal nanoparticles is attained **by non-covalently linking** through the coordinate -bonding to the metal element by the lone pairs existing in the nitrogen, oxygen or sulfur atom contained in the group", "an average particle size of said metal nanoparticles is selected in the range of 1 to 100 nm, and in the metal nanoparticle dispersion, the content of metal nanoparticles is chosen up to **40% by weight or more**", and "a volume percentage of said dispersion solvent is selected in the range of **55 to 80% by volume**."

In contrast, Hutchison teaches "substantially monodisperse ligand-stabilized nanoparticles" in which "nanoparticle" is defined as having a diameter of from about 0.7nm to about 5 nm in terms of diameter of the metal nanoparticle (core) of the "ligand-stabilized nanoparticle", which is formed in the shape of general formulas, such as CORE-(PR₃)_n, CORE-(NHR)_n, and CORE-(SR)_n. For instance, specific examples of "ligand-stabilized, metal nanoparticle" include: thiol-based metal nano-particles of the formula CORE-(SR)_n, where the R group is selected from the group consisting of phenyl, biphenyl, alkyl groups having 20 or fewer carbon atoms, and amine-based metal nano-particles of the formula CORE-(NHR)_n, where the R group is selected from the group consisting of alkyl groups having 20 or fewer carbon atoms.

In the case of thiol-based metal nanoparticles of the formula CORE-(SR)_n, such as 1.4 nm thiol-stabilized gold particles of Example 3, i.e. Au₅₅(SC₁₈H₃₇)₂₆, the thiol ligand of the formula HS-R, i.e. HS- C₁₈H₃₇, is covalently attached to the metal (i.e. Au-S-R). Thus, the thiol-based metal nanoparticles have a formula M_x(SR)_n wherein M is a metal, R is an alkyl chain or aromatic group, x is a number of metal atoms that provide metal nano-particles, and n is the number of thiol-based ligands (-SR) linked covalently to the metal nano-particles (M_x).

Accordingly, in the case of thiol-based metal nanoparticles of the formula CORE-(SR)_n, the thiol ligand of the formula HS-R is by no means non-covalently bound on the metal (M) of the metal nano-particles (M_x) via coordinate-bonding by a lone pair existing in S atom of HS-R.

In similar, in the case of amine-based metal nanoparticles of the formula CORE-(NHR)_n, the amine ligand of the formula H₂N-R is covalently attaches the amino group (H₂N-) thereof to

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the metal M (i.e. M-NH-R). Thus, the amine-based metal nanoparticles also have a formula $M_x(NHR)_n$ wherein M is a metal, R is an alkyl chain, x is a number of metal atoms that provide metal nano-particles, and n is the number of amine-based ligands (-NHR) linked covalently to the metal nano-particles (M_x).

Accordingly, in the case of amine-based nanoparticles of the formula $CORE-(NHR)_n$, the amine ligand of the formula H_2N-R is by no means non-covalently bound on the metal (M) via coordinate-bonding by a lone pair existing in N atom of H_2N-R .

Further, quantification of XPS spectra measured for the 1.4 nm thiol-stabilized gold particles of Example 31 i.e. $Au_{55}(SC_{18}H_{37})_{26}$, gave a gold-to-sulfur ratio of about 2.3: 1.0 in the term of ratio of number of atoms. The Au:S ratio obtained from XPS was confirmed by thermal gravimetric analysis, in which, on heating to 600°C, the thiol-stabilized gold particles of Example 3 display a 40% mass loss, corresponding to 26 ODT ($SC_{18}H_{37}$) ligands on an 55-atom gold nanoparticle. This result of thermal gravimetric analysis indicates that the amount of the 26 ODT ($SC_{18}H_{37}$) ligands is 40 wt. %, whereas the amount of the 55-atom gold nanoparticle is 60 wt. %, which equates to about 66 part by weight of the ODT ($SC_{18}H_{37}$) ligands per 100 part by weight of gold atoms of "nanoparticle" (core).

The molecular mass of the octadecylthiol ($H-SC_{18}H_{37}$) is 286.5, and the atomic mass of gold (Au) is 196.9. Thus, the weight ratio of $Au_{55}:(SC_{18}H_{37})_{26}$ will be $55 \times 196.9 : 26 \times (286.5 - 1) = 10829.5 : 7423 \approx 100:68.5$.

Such weight ratio of $Au_{55}:(SC_{18}H_{37})$ of 100:68.5 is not within the range of "10 to 50 parts by weight based on 100 parts by weight of said metal nanoparticles".

In the case when the gold-to-sulfur ratio of about 2.3: 1.0 is observed in the term of ratio of number of atoms, the estimated weight ratio of 2.3 Au:1.0 ($SC_{18}H_{37}$) will be $2.3 \times 196.9 : 1.0 \times (286.5 - 1) = 452.87 : 285.5 \approx 100: 63.0$. Such weight ratio of 100:63.0 is not within the range of "10 to 50 parts by weight based on 100 parts by weight of said metal nanoparticles".

The ratio of $68.5/(100+68.5)$ is 40/100, which is corresponding to the 40% mass loss observed in thermal gravimetric analysis.

In the case of such thiol-stabilized gold particles of $Au_{309}(SC_{18}H_{37})_{95}$ to $Au_{309}(SC_{18}H_{37})_{126}$, the weight ratio of $Au_{309}:(SC_{18}H_{37})_{95}$ to $(SC_{18}H_{37})_{126}$ will be $309 \times 196.9 : 95 \times (286.5 - 1)$ to $126 \times (286.5 - 1) \approx 100:44.6$ to 59.3. The ratio of $44.6/(100+44.6)$ to

59.3/(100+59.3) is 31/100 to 37/100, which is corresponding to the 33.5 % mass loss observed for the large hexadecane thiol-stabilized gold nanoparticles (diameter = 2.4 nm) in thermal gravimetric analysis. Therefore, the large hexadecane thiol-stabilized gold nanoparticles (diameter = 2.4 nm) may be such thiol-based metal nanoparticles have a formula $\text{Au}_{309}(\text{SC}_{18}\text{H}_{37})_{95}$ to $\text{Au}_{309}(\text{SC}_{18}\text{H}_{37})_{126}$, in which the ligand (-SC₁₈H₃₇) derived from hexadecane thiol (HSC₁₈H₃₇) is covalently linked to the Au nano-particle (Au₃₀₉).

At least, Hutchison fails to teach any examples of thiol-stabilized metal nano-particles or amine-stabilized metal nano-particles, in which thiol or amine is non-covalently linked to the metal nano-particles (Mx) via coordinate-bonding by a lone pair existing in S atom of H-SR or by a lone pair existing in N atom of H₂N-R. Further, Hutchison fails to provide any suggestion as to thiol-stabilized metal nano-particles or amine-stabilized metal nano-particles, in which thiol or amine is non-covalently linked to the metal nano-particles (Mx) via coordinate-bonding by a lone pair existing in S atom of H-SR or by a lone pair existing in N atom of H₂N-R.

Hutchison teaches particular features which the organic portion R of the ligand (-SR or -NHR) provides in the ligand-stabilized metal nano-particles; for instance, Hutchison suggested that alkyl groups having 2 to 20 carbon atoms of the ligand (-SR or -NHR) currently are deemed particularly suitable for forming ligand-stabilized metal nano-particles soluble in organic solvents.

For example, Example 3 provides such evidence proving that the octadecylthiol-stabilized gold nano-particle of formula $\text{Au}_{55}(\text{SC}_{18}\text{H}_{37})_{26}$, may be soluble in such organic solvent as dichloromethane (CH₂Cl₂), hot benzene, and may be suspended in acetone.

However, Hutchison fails to provide any suggestion as to level of the solubility of thiol-stabilized gold nano-particle such as the octadecylthiol-stabilized gold nano-particle of formula $\text{Au}_{55}(\text{SC}_{18}\text{H}_{37})_{26}$ in organic solvents, for instance, whether or not the octadecylthiol-stabilized gold nano-particle of formula $\text{Au}_{55}(\text{SC}_{18}\text{H}_{37})_{26}$ would be well dispersed at such high concentration as 40% by weight or more in organic solvents.

Example 8 provides evidence proving that such dilute solution of 1.4 nm phosphine-stabilized gold nanoparticles having a formula $\text{Au}_{55}(\text{PPh}_3)_{12}\text{Cl}_6$ is made by dissolving 22 mg of the phosphine-stabilized gold nanoparticles in 0.25 mL of CH₂Cl₂ and 0.25 mL of 1,2-dichloroethane. The density of CH₂Cl₂ is 1.3266 g/cm³, and the density of 1,2-dichloroethane is

1.253 g/cm³. Therefore, the concentration of the phosphine-stabilized gold nanoparticles in the dilute solution is only 3.3 wt.%. The volume percentage of the mixture of 0.25 mL of CH₂Cl₂ and 0.25 mL of 1,2-dichloroethane in the dilute solution is by no means less than 95 % by volume.

Accordingly, Example 8 fails to provide any evidence suggesting that the 1.4 nm phosphine-stabilized gold nanoparticles having a formula Au₃₃(PPh₃)₈Cl₃ would be soluble at such high concentration as 40% by weight or more in such mixture of CH₂Cl₂ and 1,2-dichloroethane. Example 8 fails to provide any evidence suggesting that such volume percentage of the organic solvent of 55 to 80% by volume would be suitably selected to form a solution of the 1.4 nm phosphine-stabilized gold nanoparticles having a formula Au₃₃(PPh₃)₈Cl₃ at such high concentration as 40% by weight or more in such mixture of CH₂Cl₂ and 1,2-dichloroethane.

At least, Hutchison fails to provide any good evidence suggesting that the level of the solubility of thiol-stabilized gold nano-particle or amine-stabilized gold nano-particle in organic solvents may be such high as 40% by weight or more. Hutchison fails to provide any good evidence suggesting that such volume percentage of the organic solvent of 55 to 80% by volume would be suitably selected to form a solution of thiol-stabilized gold nano-particle or amine-stabilized gold nano-particle in the organic solvents at such high concentration as 40% by weight or more.

In addition, the result of thermal gravimetric analysis provides good evidence indicating that dissociation of the moiety of ODT (SC₁₈H₃₇) ligand from the ODT-stabilized nanoparticle, i.e. the dissociation of the covalent bond of Au-S-C₁₈H₃₇, requires heating to such a high temperature as 600°C. Thus, the cited reference fails to provide any good evidence suggesting that the dissociation of the covalent bond of Au-S-R such as Au-S-C₁₈H₃₇ would be induced by heating at such a low temperature of 150°C to 300°C, in place of such a high temperature as 600°C. Indeed, in the thermal gravimetric analysis, the temperature for the dissociation of the covalent bond is very often measured as sharp stepwise change in the weight. Thus, the result of thermal gravimetric analysis for the ODT-stabilized nanoparticle of Example 3 provides good evidence suggesting that the dissociation of the covalent bond of Au-S-C₁₈H₃₇ is by no means observed at such a low temperature of 150°C to 300°C, but is observed only at such a high temperature as 600°C.

At least, the cited reference fails to provide any good evidence suggesting that such a metal nanoparticle, of which the surface is coated with one compound or more which has a group containing a nitrogen, oxygen or sulfur atom and capable of coordinate-bonding by lone pairs existing in these atoms as a group capable of coordinate-bonding to a metal element contained in the metal nanoparticle,

wherein the coating of said one or more compounds having the group containing the nitrogen, oxygen or sulfur atom on the surface of the metal nanoparticle is attained by non-covalently linking through the coordinate-bonding to the metal element by the lone pairs existing in the nitrogen, oxygen or sulfur atom contained in the group. Whereby, the compound that is consisting of the coating will be easily removed from the surface of the metal nanoparticle by heating at such a low temperature of 150°C to 300°C, resulting in low-temperature sintering of the metal nanoparticle, as claimed in Claim 6 of the present application.

At least, the cited reference fails to provide any suggestion as to the characteristic feature of the metal nanoparticle having the coating, which is used in the Claimed dispersion.

Furthermore, the reference fails to provide any suggestion as to a volume percentage of said dispersion solvent to be selected in the case of the metal nanoparticle having the coating, in which the one compound or more that has a group containing a nitrogen, oxygen or sulfur atom and capable of coordinate-bonding by lone pairs existing in these atoms as a group capable of coordinate-bonding to a metal element contained in the metal nanoparticle non-covalently bind on the surface of the metal nanoparticle.

The reference also fails to provide any suggestion as to an ratio of metal to the one compound or more to be selected in the case of the metal nanoparticle having the coating, in which the one compound or more that has a group containing a nitrogen, oxygen or sulfur atom and capable of coordinate-bonding by lone pairs existing in these atoms as a group capable of coordinate-bonding to a metal element contained in the metal nanoparticle non-covalently bind on the surface of the metal nanoparticle.

In conclusion, the reference fails to provide any suggestion as to all the components and amounts thereof to be selected in the claimed dispersion of the present application. Thus, the claimed dispersion is by no means obvious over Hutchison.

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Discussion of Patentability of Dependent Claims

The rest of the rejected claims depend from base Claim 1, and further define additional technical features of the present invention. In view of the patentability of Claim 1, and in further view of the additional technical features, Applicants respectfully submit that the dependent claims are patentable over the prior art.

CONCLUSION

In the light of the applicant's amendments to the claims and the foregoing Remarks, it is respectfully submitted that the present application is in condition for allowance. Should the Examiner have any remaining concerns which might prevent the prompt allowance of the application, the Examiner is respectfully invited to contact the undersigned at the telephone number appearing below.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

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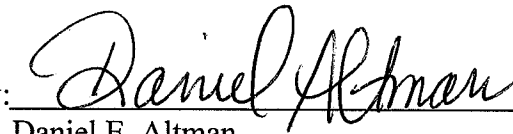
Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

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